116. Drasteria judicans.

Ophiusa judicans, Walker, Lep. Het. xv. p. 1831 (1858).
Kondowi, Lower Nyika, April 4th, 1895.
"Dusky grey moth" (*R. C.*).

117. Heterabraxas roseovittata.

♀. *Heterabraxas roseovittata*, Butler, P. Z. S. 1895, pl. xliii. figs. 2, 3.

♂. The antennæ have long radiating branches; the black markings on the primaries are better defined than in the female; the secondaries are straw-yellow, with a few scattered black spots, differing entirely on the opposite wings. Expanse 41 millim.

Not labelled: body eaten out by caterpillar of Tineid.

This is the example referred to in my previous paper and figured.

EXPLANATION OF PLATE VI.

Fig. 1. *Hyreus virgo*, p. 121.
2. *Neptis incongrua*, p. 112.
3. *Mylothris narcissus*, var. *dentatus*, p. 124.
4. ,, *crawshayi*, p. 124.
5, 6. *Teracolus infumatus*, p. 128.
7. *Heteropterus decipiens*, p. 130.
8. *Periohares albicornis*, p. 132.
9. ,, *telisignata*, p. 133.
10. *Melittia œnescens*, p. 134.

3. On the Intestinal Tract of Birds.

By P. Chalmers Mitchell, M.A., F.Z.S.

[Received December 13, 1895.]

The material upon which this paper is based consists almost entirely of birds which have died in the Society's Gardens. The work has been done in the Prosector's laboratory. I have therefore to express my great indebtedness to the Society and to its Prosector, Mr. F. E. Beddard, F.R.S.

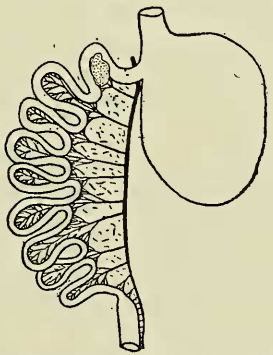
By his prolonged and beautiful investigations into the structure and disposition of the alimentary canal in birds, Dr. Gadow[1] has not only proved the taxonomic value of the intestinal convolutions in birds, but has described the details of structure in a very large number of cases. Dr. Gadow paid particular attention to the number of loops and to their disposition in the abdominal cavity. His descriptions and figures refer chiefly to the intestines as they are seen from the right side of the bird's body when the right abdominal wall has been removed. The descriptions and figures now to follow are based on the method described in my paper

[1] "Versuch einer vergleichenden Anatomie des Verdauungssystemes der Vögel," Jena Zeitschrift, xiii. pp. 92-171; pp. 339-403.—"On the Taxonomic Value of the Intestinal Convolutions in Birds," P. Z. S. 1889.—Bronn's 'Thierreich,' Vögel, pp. 591-793.

upon *Chauna*[1]. I am thus able to display more clearly the relations of the individual cases to each other and to what I take to be the primitive type, and to show the mesentery and the intestinal veins. The intestinal tract was removed from the body-cavity after section of the œsophagus and of the rectum above the cloaca. The stomach was placed to the right with its ventral side uppermost, and the loops of the intestine were folded outward. The condition of the material made it impossible to inject the vessels in enough cases to serve for comparison; but copious washing and the passage of a jet of water through the canal oxygenated the clotted blood in the veins and made it possible to trace their course. Where I was able to trace them, I found that the arteries followed the veins closely; but it is only the veins that I describe here.

In the simplest possible condition the intestine would run a straight course from the stomach to the cloaca, suspended to the dorsal wall of the body-cavity by a fold of mesentery. The intestine grows longer than the length of the body-cavity, and, in consequence, is thrown into a series of folds. The first of these, usually a single distinct loop, contains the pancreas; then follows a more irregularly folded portion, the mesentery of which is an arc of a circle, with its diameter attached to the dorsal body-wall, and the median point of its circumference stretching toward the ventral body-wall in the region where the yolk-sac was attached. The rectum is a portion of the gut which usually retains the primitive straight condition. In fig. 1, which I drew from a dis-

Fig. 1.



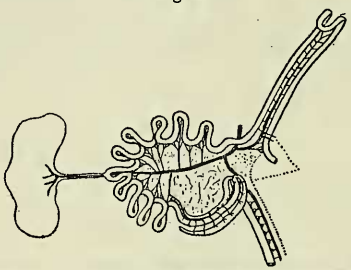
Alligator mississipiensis; intestinal tract, showing a simple condition.

[1] "On the Anatomy of *Chauna chavaria*," P. Z. S. 1895, pp. 350–358.

section I made of an Alligator, is shown such a simple mode of increase in length.

In fig. 2, which is drawn from the embryo of an Argus Pheasant about thirty days old, a primitive type of the avian intestine is shown, and it is easy to compare with this the simpler Alligator type and the more specialized arrangement in other birds. The avian intestine consists of three divisions, each typically supplied with a tributary of the portal vein. The first loop or duodenum

Fig. 2.



Argus giganteus; intestinal tract, from a chick after incubation for thirty days.

is considerably elongated, and may be folded or even spirally twisted at the free end. It contains the greater part of the pancreas, although in some cases the pancreas encroaches upon other parts of the intestine. Its mesentery is simply the elongated anterior portion of the common dorsal mesentery seen in the Alligator, and it contains the anterior mesenteric vein. The duodenum, as Dr. Gadow has shown, lies most ventrally of all the folds of the intestine, it being folded backward and downward upon the other loops. As a result of this position it frequently happens that branches of the anterior mesenteric vein leave the mesentery, and, bridging the intervening space, supply part of the posterior region of the gut. I have found these bridging-vessels remarkably constant in the groups in which they occur, and they seem to present a striking instance of a feature which, apparently, could only have arisen from the "accident" of contiguous position, and is fixed as a normal part of the structure. For where the part of the gut obtains its veins from this extrinsic source, the normal vein, a branch of the middle mesenteric vein which runs backward, is present. The bridging-vessels from the duodenum are short circuitings which have been perpetuated.

The duodenum, usually a simple loop, is in some instances expanded into a branching system of folds. This occurs in birds belonging to widely different groups, and must be taken as a convergent resemblance.

After it leaves the duodenum, the dorsal mesentery expands into a great, almost circular, fold, with the middle mesenteric vein running out to the yolk-sac in the centre of the fold. The gut is suspended at the circumference of this circular fold, and, in the simple type, is thrown into a number of corrugated folds around the circumference, which closely resemble the corrugated folds in the Alligator. At the posterior part of this circumferential part of the gut is the point where the cæca are attached, and the cæca run forward along the sides of the posterior part of this loop. In a simple case such as in this young bird the edge of the mesentery corresponding to its line of attachment, and represented by a dotted line in the figure, passes directly into the edge of the mesentery of the rectum. But in most fully grown birds the part of the gut with the attached cæca has been rotated under the rectum, that is to say over it as seen in the diagram, until the point of attachment of the cæca is brought close up to the starting-point of the duodenum. Consequently, when the gut is lying on the table with its primitive ventral side uppermost, the rectum and the rectal vessel are covered along the greater part of their length by the circular part of the gut. Finally, individual folds, from among the numerous small corrugated folds of the circular loop of gut, increase enormously in length, and Dr. Gadow has shown that the number of the loops that grow out, and the mode in which they lie, folded over or under each other within the body, are characteristic of avian groups. Where the folded loops come in contact with each other, minor short circuitings take place in the veins, and it occasionally happens, notably with Parrots, that secondary sheets of connective tissue, usually containing masses of fat, bind loops belonging to different parts of the circular fold very closely together. But even in these cases, and without difficulty in most birds, these loops may be dissected from each other, and the primitive circular loop of mesentery becomes apparent and is seen to contain the median branch of the mesenteric vein. The series of figures in this communication exhibit the gut when this unfolding dissection has been performed.

The rectum, or last part of the gut, in the vast majority of cases retains its primitive straight position, and is closely attached to the dorsal wall of the body-cavity by the posterior part of the primitive straight mesentery. The rectal vessel or posterior mesenteric vessel runs in this. It leaves the common stem of the portal vein very close to the anterior mesentery or duodenal vessel, and runs backward to the cloaca. Just in front of the cloaca a large median vessel leaves this and runs upward to the surface of the kidneys. There it forks, and each fork, after receiving several veins from the parietes, runs forward along the under surface of the kidney.

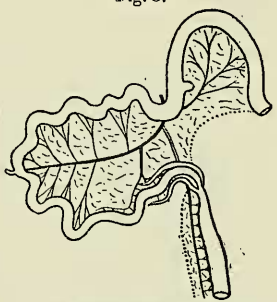
I shall now proceed to describe the deviations from this ground-type so far as I have had the opportunity of following them in the main groups of birds. The kaleidoscopic variety, in which the same

end—extension of gut—has been attained in different groups, would seem to offer a field of enquiry that may ultimately give important results bearing on the problem of divergent evolution. Dr. Gadow has shown that the modes of coiling the gut have systematic value: so far as my material has been able to take me, it looks as if the divergencies were grouped indifferently around the common type.

Ratitæ.

In the Cassowary (fig. 3) the common type is retained with an almost diagrammatic simplicity. The duodenum is a short, very

Fig. 3.



Casuarius; intestinal tract.

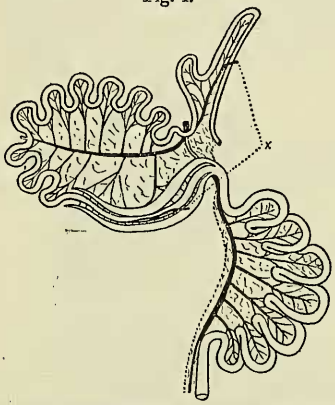
wide loop, and presents the peculiarity, which may have been an individual abnormality in my specimen, that the hepatic and pancreatic ducts open on a wide diverticulum of the distal limb of the loop. The circular fold of mesentery has the very slightly folded gut suspended at its circumference, and the remains of the yolk-sac appear as a short cæcum in the middle of the loop. The rectum is short and straight, and the cæca are in the typical position. The blood-vessels are absolutely typical.

The Emu which I examined (*Dromœus novæ-hollandiæ*) was identical in its main features with the Cassowary, and it is unnecessary to give a separate drawing. The duodenum was narrower and longer, and the hepatic and pancreatic ducts opened separately into the duodenum, not upon a common diverticulum.

The Ostrich (fig. 4), which was the fine male known as the Queen's Ostrich, presented an important deviation. The first two parts of the intestine and the three great veins were according to type, the yolk-sac diverticulum being conspicuous on the circular loop opposite the end of the median mesenteric vein. The distal limb of the duodenum presented a short lateral diverticulum, and the cæca are relatively longer than in *Casuarius* and, as has been

described frequently, were marked by the attachment of a spiral valve. But the rectal part of the intestine, that supplied by the

Fig. 4.



Struthio camelus; intestinal tract. *x*, short-circuiting vessel cut across.

posterior mesenteric vein, is expanded into an enormous coil swung at the circumference of a semicircular expansion of its mesentery. Only in *Chauna* and in the Eagles and Petrels have I found the slightest trace of a convergent resemblance to this feature, but in the latter the subsidiary rectal loops, although supplied by the rectal vessel, lie above the cæca.

I have not yet had an opportunity of dissecting a Rhea or an Apteryx [1].

It is plain that, so far as degree of divergence of type in the alimentary canal goes, the Ratites deserve their accepted place at the bottom of the avian scale.

Carinatæ.

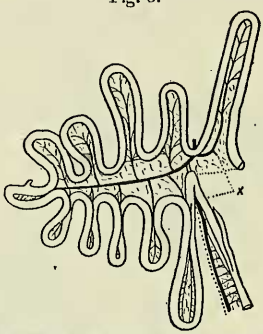
Colymbiformes.

In these (*Podiceps* not examined) (fig. 5, p. 142) the duodenal loop is straight and normal. The circular loop is pulled out into a series of minor loops that are arranged almost symmetrically round the middle mesenteric vein. The yolk-sac vestige lies in front of the middle point of the series. The last loop of the circular system

[1] [In a *Rhea americana* which I have more recently examined the gut was intermediate in form between those of *Casuarius* and *Struthio*. The anterior portion resembled *Casuarius*; the rectum had an expansion recalling that in the Ostrich, but much less strongly marked.—P. C. M., *March* 1896.]

is longer than the others, as frequently happens when the cæca are relatively short. It is drained partly by the duodenal vein.

Fig. 5.



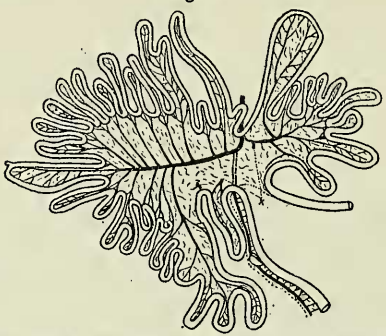
Colymbus septentrionalis; intestinal tract. *x*, short-circuiting vessel from duodenal to posterior mesenteric vein cut across.

The last part of the intestine is long and straight, and the posterior mesenteric vein drains the cæca and part of the region in front of the cæca.

SPHENISCIFORMES.

In these (fig. 6) the primitive arrangement is disguised by the enormous length of the gut and consequent complexity of the

Fig. 6.



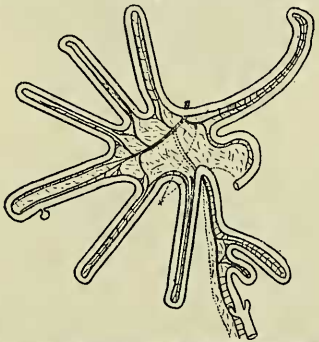
Eudyptes chrysocome; intestinal tract. *x*, short-circuiting vessel cut across.

three parts. In *Eudyptes chrysocome* the duodenum forms a subsidiary system of loops; in *Aptenodytes pennanti* a spiral, bearing a convergent resemblance to the duodenum of the long-gutted Sea-Eagles. The circular loop is thrown into an enormous series of minor folds, about the middle of which, but in a position similar to that in the Divers, occurs the yolk-duct vestige. The last two loops are supplied from the duodenal vessel. The posterior part of the gut is quite like that of the Diver, although the cæca are still further reduced.

Procellariiformes.

The Northern Petrel (fig. 7) presents several interesting modifications of the type. The duodenum is compound, the first part being twisted round the small gizzard, the second part forming a

Fig. 7.



Fulmarus glacialis; intestinal tract. *x*, short-circuiting vessel cut across.

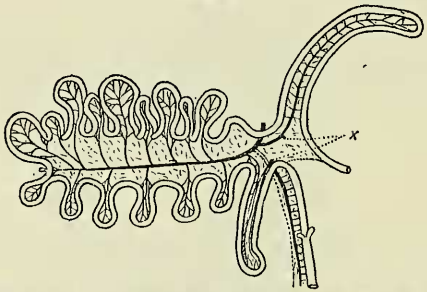
long loop containiug the pancreas in the typical fashion. The circular loop is drawn out into a number of straight narrow loops, on the fourth of which occurs the vestige of the yolk-duct. The last loop is drained partly from the normal source and partly by a short-circuiting vein from the duodenum. The posterior part of the intestine is like that of *Colymbus* and the Penguin, with the exception that, as in the Sea-Eagle, the portion of the gut supplied by the posterior mesenteric vessel, but anterior to the origin of the cæca, is expanded into two subsidiary loops.

Ciconiiformes.

The birds in this group that I have examined have all departed similarly from the type. The whole intestine is enormously elon-

gated, the greater part of the elongation having occurred in the circular loop. The cæca are small, and lie on the third part of the gut, some distance below where it joins the circular loop. As usually happens when the cæca are reduced, the last part of the circular loop is pulled out into a long free loop, which, in the natural position, is closely attached to the under surface of the duodenum, and gives a vein to the duodenal vein. *Platalea leuco-*

Fig. 8.



Platalea leucorodia; intestinal tract. *x*, short-circuiting vessel cut across.

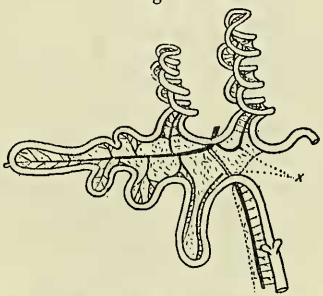
rodia, the Spoonbill (fig. 8), shows the least differentiation among those that I have examined. The duodenum is very long and is curved far round to the left in the abdominal cavity. The circular loop is enormously expanded, and forms a rough spiral, of which the middle mesenteric vein, running out to the vestige of the yolk-duct, forms the axis. The figure represents this after it has been dissected out and is more diagrammatic than most of the drawings I give. The most important points to which I would call attention are: that the yolk vestige, though at the end of the spiral, is much nearer the posterior than the anterior end of the circular loop, owing to the greater development of the first half of the circular loop; and the fact that on the whole the minor loops of the circular loop are of similar length, with the exception of the last loop. It is in this respect especially that the Spoonbill has departed less than other Ciconiiformes from the type. The veins of the gut are almost diagrammatic in the simplicity of their arrangement, the only peculiarity being the short-circuiting branch from the duodenal vein to the distal loop of the circular loop.

In *Pseudotantalus ibis* the duodenum, which was curved in *Platalea*, is very much elongated and twisted into a spiral. The first portion of the circular loop is elongated into a separate loop: the remainder of the circular loop is more primitive even than in *Platalea*, consisting of a number of nearly equal radial folds at the circumference of the whole fold. There is a very

slight spiral twist, the axis of which is the middle mesenteric vein, which runs out to the yolk-duct vestige. The last loop and the third part of the intestine, and the veins, are as in the Spoonbill.

Ciconia alba, *Ciconia nigra* (fig. 9), *Leptoptilus crumeniferus*, and *Leptoptilus argila* show the tendency to form spirals which is present throughout this group in an increasing degree. In these four birds the duodenum forms a spiral which, in *C. nigra*, is

Fig. 9.



Ciconia nigra; intestinal tract. *x*, short-circuiting vessel divided.

twisted with a spiral formed from the first subsidiary loop of the circular loop. The remainder of the circular loop is elongated in them all, and the yolk-duct vestige occurs at the elongated point. The last loop of the circular system and the third part of the gut and the veins occur in the fashion typical of the whole group.

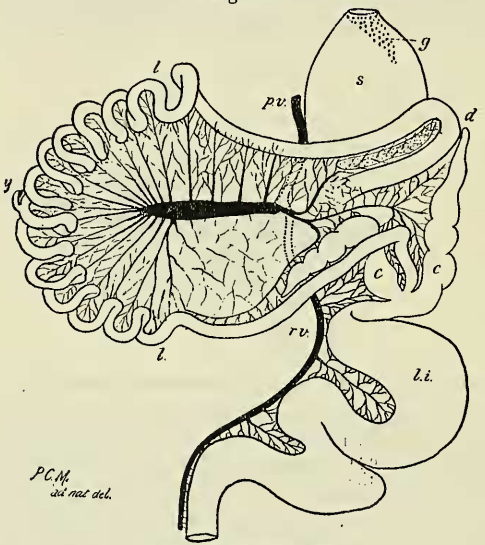
Pelecanus fuscus, which is the only Steganopod I have examined, displays a simple variety of the Ciconiiform type. The duodenum is straight and encloses a curiously lobulated pancreas. The circular coil begins with a short straight minor loop, and then forms an enormous bunch of short equally sized loops, supplied by radiating branches of the middle mesenteric vein. Upon one of these, nearer the posterior than the anterior end, occurs the yolk-duct vestige. The end of the circular loop is drawn out into the usual loop, with a short-circuit vein from the duodenum, and the third part of the gut is as in the other Ciconiiformes.

Anseriformes.

The striking character of the Anseriformes is the small deviation from the primitive type represented in their intestines. As I have already pointed out in a communication on the anatomy of *Chauna*, the gut of that bird has deviated from the avian type even less than the gut of the Ostrich. The result is a very striking similarity between the gut of the Struthious birds, of *Chauna*, and of an

immature Gallinaceous bird. I reproduce here a cut from my paper on *Chauna* (fig. 10). The duodenum is a distinct fold, and the duodenal vein receives short-circuiting branches from the

Fig. 10.



Intestine of *Chauna chavaria*.

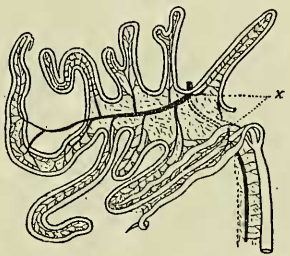
s. Proventriculus with *g* the glandular patch.
d. Duodenum enclosing the pancreas (the duodenum has been turned forward).
l to *l*. The large loop of the intestine, with *y* the yolk-sac diverticulum about the middle of its length. This coil has also been raised up and turned forward. The remains of the ventral mesentery running from the diverticulum are not shown, as they lie under the intestinal loop.
c c. The cæca. *l.i*. Large intestine.
r.v. Rectal mesenteric vein. This dips under the mesentery of the large loop, where its course is shown by a dotted line. It there joins with the large central vein of the large loop and with the veins from the duodenum and cæca, and the blood passes forward, its course being shown by a dotted line, to the portal vein *p.v*.

hinder region of the circular fold, especially from one of the cæca, which, in the diagram, is represented as turned outwards. The circular loop differs in no essential respect from the primitive avian type, as displayed in the Ostrich and young Argus. The

resemblance to the Ostrich is heightened by the fact that in *Chauna* and the Ostrich the rectum, by being thrown into a subsidiary set of folds, departs in a similar way from the common type. The resemblance between *Chauna* and *Rhea* is very striking.

The Ducks and Geese (fig. 11) display a very definite and simple modification of the ground-type. It consists simply in the elongation of a limited number, generally five, of the primitive irregular loops of the circular loop. In a young *Bernicla magellanica*, still in its down plumage, the duodenum and the third part of the gut were in the typical condition, but the circular loop was already pulled out into three or four subsidiary loops, of which the longest bore the yolk-duct vestige. In adult Ducks, Geese, and Swans the arrangement differed in no essential respect from the drawing

Fig. 11.



Cygnus atratus; intestinal tract. *x*, short-circuiting vessel divided.

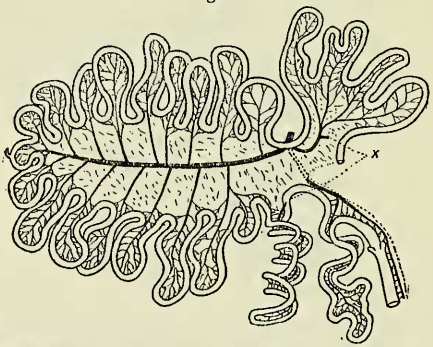
(fig. 11). The duodenum was simple. The duodenal vessel received short-circuiting veins from the hinder portion of the circular loop. A striking feature of the minor loops on the front part of the mid-gut is the presence upon them of minor loops. The circular loop had a huge median mesenteric vein, which ran out to the much elongated subsidiary loop bearing the yolk-duct. It gave off three vessels to three expansions of the proximal part of the circular loop, vessels to a long and short distal expansion, and a vessel to the straight part of the loop along which the cæca were attached. The rectum was straight and in the typical fashion was supplied by a posterior mesenteric vein.

Falconiformes.

I have not had the opportunity of examining any of the Cathartæ. The Accipitres show a marked divergence from the common type. The gut generally is enormously long, especially in the fish-eaters. From the point of view of relation to type, I cannot see that there is any special relation between the Accipitrine deviation and the

deviation among the Pelargi, although Dr. Gadow has laid some stress on the existence of such a resemblance. In some of the Vultures and Falcons there are spirals formed by the subsidiary loops, just as occurs, for instance, in *Ciconia* (fig. 9). On the other hand, members of both groups exhibit a much simpler method of attaining increased length, and this seems to imply that the spiral formation is a convergent resemblance. When the simplest members of the groups are taken—I am speaking of them only from the point of view of gut-formation—the special spiral formation disappears and the relations between the groups are only their relations to the common type. The White-tailed Sea-Eagle (fig. 12) shows the general character of the group. Its gut is very long, and if the spiral twists were a character of the

Fig. 12.



Haliaëtus albicilla; intestinal tract. *x*, short-circuiting vessel divided.

group one would expect the increased length to be displayed in the formation of complicated spirals. This does not occur. The duodenum is thrown into a complicated set of subsidiary loops, thus recalling the similar modification in the Penguin. Among the Accipitrines generally the duodenum is a very wide irregular loop, but I have not found it thrown into secondary loops in other cases. The circular loop forms a very extended set of minor loops, some of which, especially on the lower side, are slightly twisted into spirals. In other Accipitres it is more often the upper loops of this series that are twisted. The vestige of the yolk-duct occurs at the end of the median mesenteric vein in the typical fashion, but is situated rather nearer the proximal end of the loop. The last loop of the circular system is very long and usually, as in *Haliaëtus*, spirally twisted. It gives a short-circuiting vein to the duodenal vein. The part of the hind gut between the cæca and the circular loop is thrown into a complicated set of folds,

supplied by the posterior mesenteric vein. This structure is present in all the Accipitres I have examined, and Dr. Gadow states that all the Accipitres and Cathartæ have irregular kinks above the rectum. A similar deviation occurs in the Petrels (fig. 7, p. 143).

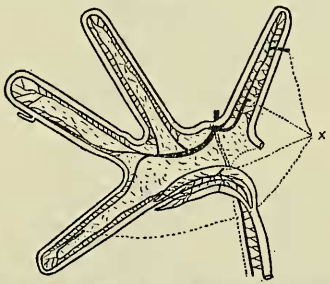
Galliformes.

I have not had the opportunity of dissecting any Galliformes except Galli. The figure of the young Argus Pheasant (fig. 2) may serve as a type for the adult intestine of the Peacocks, Fowls, Quails, Tragopans, and so forth. The three great portions of the intestine and the three great mesenteric veins are always present in the typical form. The adult shows the vestige of the yolk-duct at the end of the middle mesenteric vein. Branches radiate off from the middle vein to the irregular loops of the circular fold, and the last part of the circular fold, along which the enormous cæca lie, is drained partly by a recurrent branch of the middle mesenteric vein and partly by short-circuiting branches from the vein of the duodenum. The rectum is always straight.

Gruiformes.

Like the Galliformes, the Gruiformes closely conform to the primitive type. The gut is short, and instead of being thrown into a number of irregular minor loops the subsidiary loops are

Fig. 13.



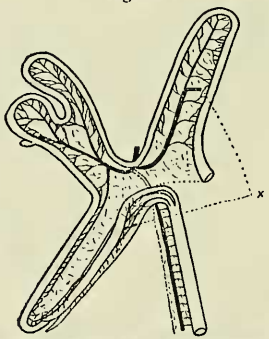
Crex pratensis; intestinal tract. *x*, short-circuiting vessel divided.

few in number and definitely placed. The Common Land-Rail (fig. 13) may be taken as typical of the Rallidæ. *Porphyrio* and *Aramides* are practically identical with it, and the Cranes and *Psophia* differ only in minor particulars. The duodenum is a narrow regular loop: the circular loop is pulled out into four narrow subsidiary loops; upon the distal limb of the second subsidiary loop the vestige of the yolk-duct is found. This is very large and is bound

down by the remnant of a primitive ventral mesentery. The last minor loop of the circular portion of the gut has the long cæca running forward alongside it. It is drained in the usual fashion by a branch of the mid-mesenteric vein and by short circuit branches from the duodenal vein. At first sight there is a striking similarity between the gut of the Rails and the gut of *Fulmarus* (fig. 7, p. 143); but this is due simply to the narrowness and regularity of the loops. The position of the yolk-duct vestige differs in the two, while the short cæca and the kinks immediately above them make absolutely distinctive characters in the Petrel.

In the Dicholophidæ and the Otididæ the Ralline characters are still obvious, but the gut is still shorter and the loops more definite. *Cariama cristata* (fig. 14) shows the duodenum and the rectum identical with the Rails; the last portion of the circular loop is

Fig. 14.



Cariama cristata; intestinal tract. *x*, short-circuiting vessel divided.

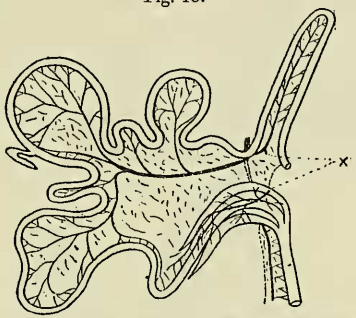
identical in its arrangement and veins, although the cæca are still larger. The rest of the mid-gut is reduced, the third loop being absent. The yolk-duct vestige is in the same place upon the second loop, but the first loop of the circular mid-gut is partly united with the second. In the Otididæ the gut appears to be further modified in the direction in which *Cariama* differs from *Crex*. The duodenum, the rectum, and the last loop of the mid-gut are as in the Rails and *Cariama*; but the remainder of the mid-gut is reduced to a single loop, corresponding to the second of that region in *Crex*, and bearing the yolk-sac vestige on its distal limb.

Charadriiformes.

The birds associated in this Order display a very varied series of divergences from the type. Among those Limicolæ that I have

examined, *Numenius* (fig. 15) certainly is nearest the common type. The duodenum is a simple loop supplied with the usual vein; the circular loop is nearly symmetrical, and the vestige of the yolk-duct

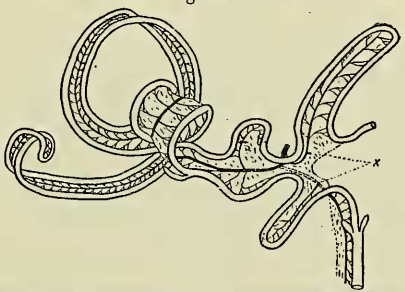
Fig. 15.



Numenius arquata; intestinal tract. *x*, short-circuiting vessel divided.

occurs about the middle of its length. As in the Rails this is remarkably large even in adult life, and frequently is bent on itself and tied down by remains of the primitive ventral mesentery. The long cæca lie alongside the posterior part of the circular coil, which gives a short-circuiting vein to the duodenal vessel. The rectum is straight. *Glareola* resembles *Numenius*, but is even simpler. In other Limicolæ the general tendency is to an asymmetrical extension of the circular loop and to a reduction of the cæca. The Woodcock (fig. 16) may be taken as an extreme case of this kind of divergence. The general arrangement of the loops

Fig. 16.

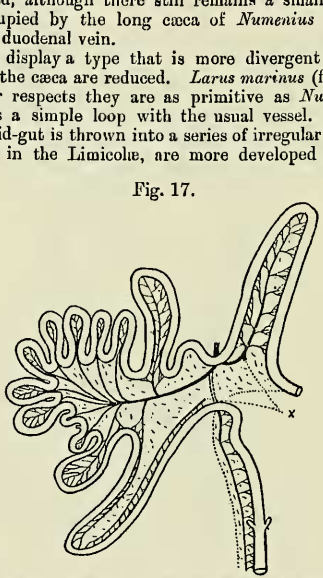


Scolopax rusticola; intestinal tract. *x*, short-circuiting vessel divided.

and blood-vessels remains as in *Numenius*; but the large subsidiary loop, on the distal limb of which lies the yolk-sac vestige, is pulled out into an enormously long narrow loop, which is then rolled up into a spiral. The distal part of the circular loop is very much reduced, although there still remains a small loop in the position occupied by the long cæca of *Numenius* and giving a vessel to the duodenal vein.

The Gulls display a type that is more divergent than *Numenius*, in that the cæca are reduced. *Larus marinus* (fig. 17) shows that in other respects they are as primitive as *Numenius*. The duodenum is a simple loop with the usual vessel. The circular coil of the mid-gut is thrown into a series of irregular loops, which, however, as in the Limicolæ, are more developed on the side

Fig. 17.



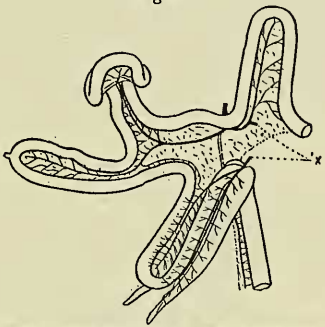
Larus marinus; intestinal tract. *x*, short-circuiting vessel divided.

anterior to the yolk-sac vestige. This lies in the normal position opposite the end of the median mesenteric vein. The last part of the circular loop forms an extended subsidiary loop supplied by a short-circuiting vein from the duodenal vessel. I have not found instances myself, but Dr. Gadow states that in some Gulls spiral folds occur in the region corresponding to the spiral fold of *Scolopax*. Thus the Gulls and the Limicolæ would form a series of divergences from the common type, but in parallel directions.

Pterocles (fig. 18) diverges in yet another direction. The extremely primitive character of the gut is obvious at once. The duodenum, the circular loop, and the rectum are all distinct and have the usual veins. The middle of the mid-gut is marked by the vestige of the yolk-sac placed at the end of the median mesenteric vein. As in Charadriiformes generally, the anterior portion

of the circular loop is expanded. In *Pterocles* it forms a long narrow loop, the end of which is bent upon itself. The posterior

Fig. 18.

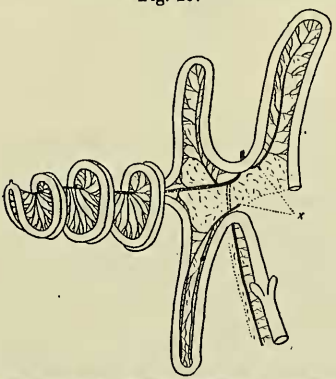


Pterocles bicinctus; intestinal tract. *x*, short-circuiting vessel divided.

part of the circular loop remains in the primitive condition, and has the long cæca attached to it. A short-circuiting vein from the duodenum is present. The rectum is straight.

In the Columbæ which I have examined (*Columbæ* of several species, *Phlogœnas cruenta*) (fig. 19), it is tempting to regard the

Fig. 19.



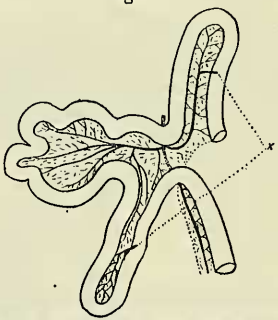
Columba livia; intestinal tract; the spiral is figured as rather too symmetrical. *x*, short-circuiting vessel divided.

gut as a simple derivative of the type seen in *Pterocles*. The duodenum is longer and narrower. The circular loop is enormously expanded, but the three subsidiary loops seen in *Pterocles* remain. The first of these is somewhat shortened; the second, that bearing the yolk-sac vestige at its end, is enormously lengthened; the mesentery is folded along the line of the median mesenteric vessel, so that the two limbs of the loop are brought in contact with each other, and, finally, the whole folded loop is rolled into a rough spiral. The third subsidiary loop of the circular part of the gut has the same arrangement and veins as in *Pterocles*; but the cæca no longer run along it, but occur as very short stumps upon the rectum.

Cuculiformes.

Of these, I have examined only *Corythaix* (*chlorochlamys* and *persa*) and a number of Psittaci. So far as I can see, one has to go back to the common type for both. *Corythaix* (fig. 20) has a remarkably short and wide gut, in correspondence with its frugi-

Fig. 20.



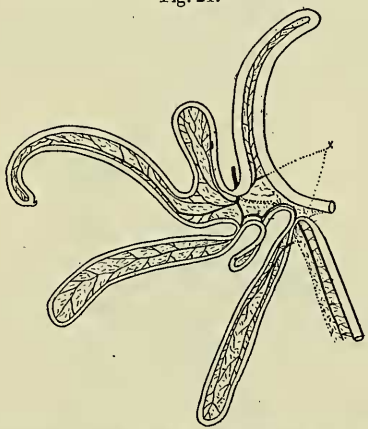
Corythaix chlorochlamys; intestinal tract. *x*, short-circuiting vessel divided.

vorous habits. The duodenal loop is wide and straight. The circular loop is short; its anterior portion forms a normal coil, is slung at the circumference of the circular mesentery, and is supplied by radiating branches of the median mesenteric vein. No doubt the vestige of the yolk-duct occurs upon this; but in my specimens, which were all affected with tubercular nodules on the gut, I failed to identify it. The distal portion of the circular coil, along which the cæca run in the primitive type, is pulled out into a narrow subsidiary loop, the distal portion of which gives a short-circuiting vein to the duodenal vein. The rectum is straight, and there was no trace of cæca. The gut appears to be directly derived from the primitive type by shortening and by loss of the cæca, the distal

loop of the mid-gut with its special vein apparently being a reminiscence of the stage with functional cæca.

In the Parrots, Macaws, and Parrakeets that I have examined the gut presents no great divergences. It is invariably very long and slender, and the subsidiary loops are folded upon each other, and twisted and doubled in a very perplexing manner. Moreover, the masses of twisted gut are overgrown by connective tissue loaded with fat, and short-circuiting connections between the veins are common. The relation to the common type, however, is easily made out. *Ara ararauna* (fig. 21) may serve as an instance; the

Fig. 21.



Ara ararauna; intestinal tract. *x*, short-circuiting vessel divided.

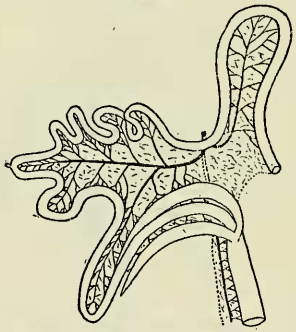
duodenum is considerably wider than the rest of the gut, and is a simple loop, partly curved at the end. The circular loop is enormously expanded and is pulled out into a number of subsidiary loops, four in number, as in *Ara*, but numerous minor subsidiary loops usually occur between them. The first of the four is short in *Ara*; the second, as in the others that I have examined, bears the vestige of the yolk-duct at its extremity; the third and fourth are very long, and the fourth has a short-circuiting vein to the duodenum, and corresponds to the part of the circular loop along which the cæca run in the primitive type. The rectum is straight and bears no trace of cæca. The three main veins—the duodenal, the median, and the posterior mesenteric—occur in the typical fashion. When the minor loops between the four subsidiary loops are abundant, as, for instance, in *Chrysotis*, the gut bears a resemblance

to that of the Accipitres ; but this, I think, is superficial, and merely due to the relation to the common type. The marked features of the divergence from type in the Psittaci consist in the elongation of a definite number of loops and in the matting of these loops together, the loops being folded over each other backward and forward. There is no trace of the formation of a loop supplied by the posterior mesenteric vessel, which is the most striking Accipitrine character.

Coraciiformes.

Of the birds in this group that I have examined, the Owls (fig. 22) and Caprimulgidæ are the most primitive, and indeed differ very little from the primitive type. The duodenal loop, as in other Coraciiform birds, is very wide, especially towards its extremity. The circular loop of the gut remains in nearly the primitive con-

Fig. 22.

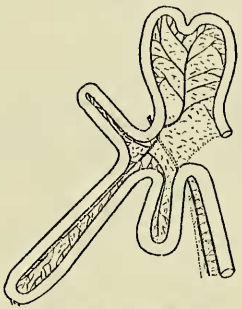


Bubo maximus; intestinal tract.

dition, being thrown into a series of short convoluted lobes, supplied by radiating branches from the middle mesenteric vein. In *Bubo maximus*, where the gut is relatively short, the only subsidiary loop of the mid-gut series that is prominent is the distal loop, along which, as in the common type, the large cæca run forward. In other Owls there is frequently another well-developed subsidiary loop on the part of the mid-gut between the duodenum and the vestige of the yolk-duct. The rectum is straight. The three branches of the portal vein, the duodenal, median, and posterior mesenteric veins, all are in the typical condition. I have not been able to see many of the other birds in this group which possess long cæca. Those without functional cæca display very simple divergences from the common

type. The wide gut is very short: the Colies, for instance, have shortest guts of any birds that I have examined; but the same general features are present in all. *Rhytidoceros plicatus*, for instance (fig. 23), shows the duodenum as a very wide irregular

Fig. 23.

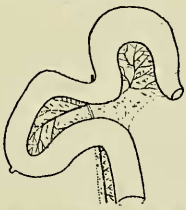


Rhytidoceros plicatus; intestinal tract.

loop, with a pucker at its closed end. The circular part of the gut is thrown into three simple subsidiary folds. The first of these corresponds to that present in most Owls, but absent in the Eagle-Owl; the second bears the yolk-sac vestige at its extremity, and the third corresponds to the part along which the lost cæca lay. The rectum is straight. The veins are in the typical form, and I have not found any short-circuiting veins.

In the Woodpeckers (*Gecinus*) and Toucans (*Rhamphastos*) the duodenum is equally wide: the three loops of the mid-gut are present with the yolk-sac vestige on the median loop; but all three loops are much wider and shallower than in the Hornbill. The

Fig. 24.



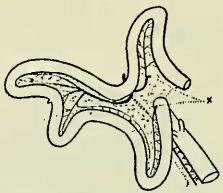
Colius capensis; intestinal tract.

Colies (fig. 24) have the same parts, but still wider and shallower. At first sight the gut of the Coly seems very different from that of the Hornbill. But the vestige of the yolk-duct orients the apex of the middle subsidiary loop of the mid-gut: the anterior and posterior loops of the mid-gut may then be seen as simple shallow curves on the gut. The wide duodenum and the straight rectum, and the veins, are as in the Hornbill and Woodpecker.

Passeriformes.

I have proceeded only a short way in the examination of the members of this vast group, but those that I have examined show a simple and identical modification of the common type. *Parus major* (fig. 25) may serve as a fairly generalized example of the Passerine type. The duodenum is a simple loop. The circular coil of the mid-gut shows a tendency to be spirally twisted, the

Fig. 25.



Parus major; intestinal tract. *x*, short-circuiting vessel divided.

vestige of the yolk-duct forming the apex of the spiral, and the median mesenteric vein forming the axis of the spiral. The spiral is hardly visible in *Parus*; it forms less than half a turn. In the Crows and Nutcrackers, and in a very large number of other Passeres, the spiral is long and forms several turns. Between the spiral and the rectum there is a subsidiary loop on the mid-gut where in the primitive type the cæca ran forwards. This in *Parus* and in all other Passeres I have examined is closely connected with the duodenum, which is folded under it. Frequently a lobe of the pancreas passes across and lies in this subsidiary loop. The loop has a recurrent vein from the middle mesenteric vein, and a short-circuiting vein or veins opening into the duodenal vein. The rectum is short and straight, and where these are present, as in *Parus*, bears the cæca. The veins are normal.

Some Passeres, as, for instance, the Nutcracker, show signs of a subsidiary loop of the mid-gut between the spiral and the duodenum. In others, as, for instance, the Poë Honey-eater (*Prosthemadera*), the anterior part of the mid-gut and the spiral are reduced to practically a simple fold, while the last loop of the mid-gut is considerably expanded.

Conclusion.

I do not feel justified in attempting to draw any general conclusions as to the relations of the various divergences from the common type that I have described; but I think that I have brought together enough matter to show that when a much larger number of facts has been collected, the method of investigation I have been following may furnish another clue to that riddle of zoology, the classification of birds. But in addition to this systematic interest, the comparative anatomy of a group of creatures so large in numbers and so alike in anatomical structure offers a field for the investigation of the innumerable divergences and convergences that have taken place in the evolution of the group. I cannot see that interpretations of isolated characters have any value. When we know the comparative anatomy of the greater number of characters that make up an animal, and not only those that seem to distinguish it as a species, the time may come for interpretation. But to those who care for discussions concerning isolated characters, I may suggest the problem: in these loopings of the gut in birds, there is an almost kaleidoscopic variety, and apparently these varieties are of systematic value; what are their utilities?

4. Myology of Rodents.—Part II. An Account of the Myology of the Myomorpha, together with a Comparison of the Muscles of the various Suborders of Rodents. By F. G. Parsons, F.R.C.S., F.Z.S., F.L.S., Lecturer on Comparative Anatomy at St. Thomas's Hospital.

[Received December 14, 1895.]

The present paper is intended to be a second instalment to the one "On the Myology of the Sciuromorphine and Hystricomorphine Rodents," which I had the honour of reading before this Society in 1894 (see P. Z. S. 1894, p. 251). I am again indebted to the kindness of the Society's Prosector, Mr. F. E. Beddard, for a large proportion of my material; indeed, it was his suggestion that a detailed examination of the muscles of Rodents would be of practical value in the Dissecting-Room at the Gardens that determined me to undertake the work in the first instance.

The first part of this paper contains an account of the muscles of thirteen Myomorphine Rodents, and as a statement of actual facts will, I hope, prove of some value.

The second part is devoted to a series of summaries and generalizations founded upon the facts with which these and previous dissections have furnished me. This part I regard as of less value than the first, because future dissections may make many alterations necessary. It seems well, however, to take stock of the mass of material from time to time as it accumulates.